A Mixed Reality based Training Application for an oil refinery

Working within oil refineries is a very responsible task that requires highly trained and well-educated personnel. They need both a good theoretical knowledge about the processes that place within the vessels and tanks of the refinery and also a very good practical hands-on knowledge about the different devices and their interdependencies.
Mixed Reality techniques are used to present such location specific information right on the spot. This combines the advantages of conventional classroom training and on-site inspections, because the trainee has on the one hand the experience of the real plant context and on the other hand access to all information that is available in the classroom.

1. Introduction and Motivation

The average refinery employee is a well trained expert in the fields of chemistry and/or petrochemical processes. Despite the fact that these new employees are both trained in theoretical and practical manner, it is often difficult for them to become acquainted with the complexity of the refinery.
The difficulties that arise by training a new refinery employee are visualized in Figure 1: After learning basic skills, a new employee can easily understand a schematic plan of a plant. But it is really hard for the employee to match the schematic diagram of a plant into the real machinery. Without the help of a trainer, who is familiar with the refinery, a new employee would barely be able to learn how to operate. Our goal of the application is to provide new and more efficient training tools for the refinery environment to transfer knowledge from highly skilled operators to new employees. The application, which is based on the AMIRE framework [4], provides features that help to tame this complexity. By using MR based technologies, the application enables the user to find corresponding counterparts in the schematic diagram and the real plant. The MR application consists in several stations (so called checkpoints) that are assigned to specific refinery devices like columns, pumps and vessels, which are essential for the production process. These stations are connected by so called navigation ways. These navigation ways are implemented by videos that show a person walking from the source station to the destination station.

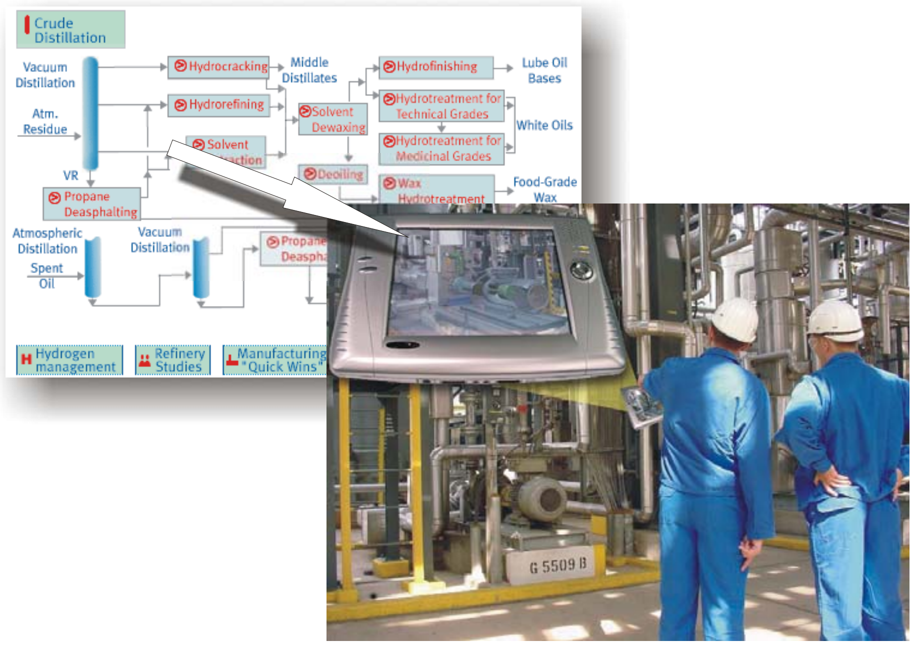

Figure 1: Plant schema and its translation into real machinery. Using MR technology with Tablet-PC would help employees during this process.

2. Related Work

A lot of research has been invested into developing training applications for industrial partners – also in the area of Mixed Reality and Augmented Reality. ARVIKA, one of the highlights in this area showed very successfully that new research areas (as MR/AR is at the moment) are far away from the industrial benefits; but it is necessary to get more and more fruitful discussions between industrial partners and researchers [2], [3]. Especially in car industry, we find a lot of MR/AR based applications [6], [7]. Most of the time, research labs have fantastic ideas, but the industry wants to have something completely different. On the other side they don't care about the newest possibilities of a technology, but they want to use it – otherwise the applications are senseless. Navab described in [1] that industrial R&D laboratories have to pay attention to future commercialization; toy applications are nice, but useless for industry. Boeing gave the best example with the first AR application for the mechanics that are guided step-by-step through a disassembly procedure. The application was nice – but it failed because of the bad hardware at that time and because of the users' acceptance to use it during production. Consequently, a closely cooperation between the programmers and the end-users, the experts in their area, would be needed.

3. Requirements

The requirements for the refinery application where specified during several sessions with the customers. The following list describes the most important non-functional requirements:

- **Small and lightweight device:** The user is already burdened with heavy protection gear. Thus, employees cannot be additionally encumbered by a heavy and oversized computer device.

- **Real-time:** The application should respond in real-time to changes of the environment (e.g. tracking of the user's viewpoint).

- **Easy and intuitive user interface:** The refinery is a very dangerous and complex environment. The users' mind should not be distracted from their dangerous environment.

But the requirement for a small and lightweight is in contradiction to the requirements for real-time processing and an easy and intuitive interface, because even today, a device that provides a powerful graphics performance has a considerable size and weight. Even the usability of the user interface can be declined by a small display. The optimal user interface for AMIRE was the Tablet-PC, because it was a good trade-off between processing/graphics power and the size. Moreover, our Tablet-PC has a mounted camera that provides a video image of the environment.

The most important functional requirements can be defined as follows:

- **Video overlay:** It should be possible to overlay videos and 3D data with the environment video. This feature should enable the user to look inside the machines – as it can be done with a magic lens.

- **Image viewer**: Different images, schemas, and 2D data, like blueprints of some devices, should be displayed.

- **Navigation:** The application should provide an easy to use navigation tool that guides the employees through the plant.

- **Tracking:** Navigation and correct 3D overlay over existing devices requires accurate tracking.

4. The MR training application

The application is designed as a network of different AMIRE components. Those components provide generic configuration and connection interfaces, which are tailored to the needs of the authoring system of AMIRE [10].

Figure 2: Two snapshots of the application - the user views a video that shows the way to the next station.

The basic layer of the application is built out of so called programmed components, like animation components for loading 3D data or movies, video overlay components, tracking components and several conventional GUI components. Tracking for example is currently performed by several ARToolKit components [5], but the component approach enables relatively unobstructed partial or complete exchange of the tracking system.

Moreover, AMIRE allows the creation of so called composed components, which are built out of entire component network. Such composed components form the middle layer of the application. These components are more or less application dependent, because they map behavior that is specific for the application. Especially the GUI is implemented by such composed components to firstly encapsulate the complexity of the user interface semantic and secondly to foster a consistent user interface. Figure 2 shows a composed component that implements the main menu of the application on the right side, a composed component to control the video, which itself consists in a menu component that provides control elements for the video manipulation (e.g. play mode etc.); moreover, the menu includes a slider that allows direct manipulation of time and a background image. The top layer of the application, which contains its more global behavior of the application, like the navigation connections between different stations, the interconnection between different content components and GUI component was authored with the authoring tools based on the AMIRE environment. These tools and their use are described in the following section.

5. Authoring of the application

One of our goals was to enable also inexperienced programmers or even people without any programming skills to do smaller maintenance or extension tasks on the application on their own. Therefore, we have chosen the aforementioned AMIRE framework. However, a component–based framework does not provide this kind of maintainability that we require. But an authoring tool for this component-based framework, which uses also Mixed Reality technology, does so. We have analyzed the authoring process of our application and encountered three basic features:

- The first one is to create new components and to configure the initial behavior of each component.

- The second one is to describe the workflow by connecting them (component routing).
- The third one is to easily calibrate the placement of all virtual content that augments the real scene.

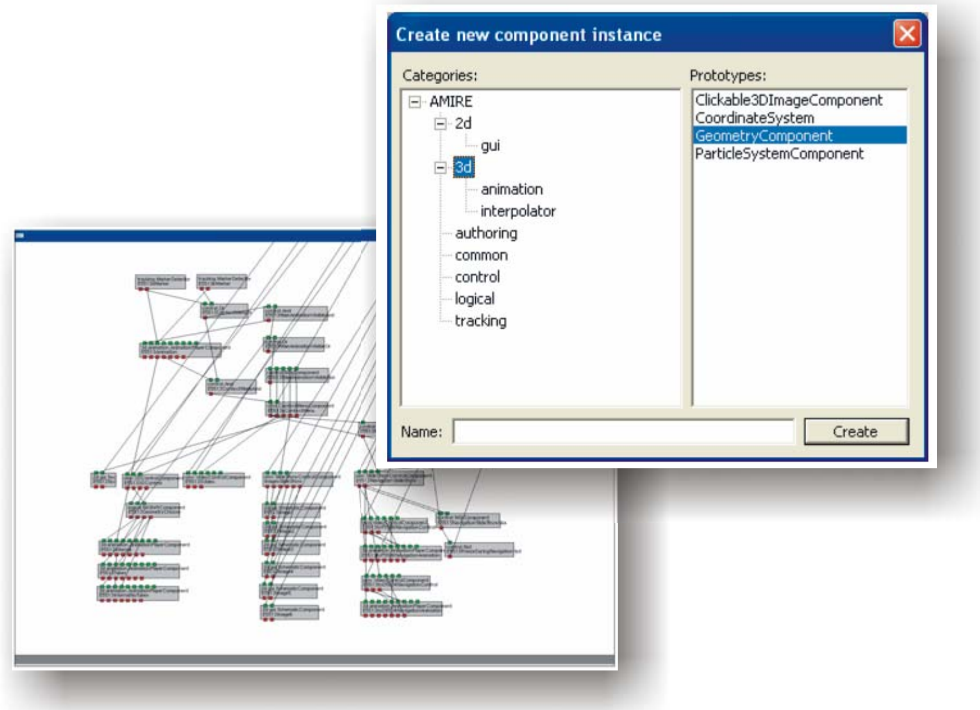

Figure 3: Authoring component schema.

Figure 3 depicts the basic component routing and creation process in some screenshots of such an authoring tool. The first image shows a dialog that allows us to create new components by choosing them from several hierarchical categories. The second image depicts a part of the application's component schema.

We configure the initial behavior of a component by a property dialog. However, specialized editors for specific kinds of properties can easily extend this generic interface. By selecting a color in a color-chooser dialog for example the author easily configures a color property, and a file-browser dialog simplifies the configuration of a file property.

On the one hand we have a generic configuration tool, which allows us to modify every single property of a component. On the other hand we have two configuration tools specialized on the placement of virtual content. Both placement tools are depicted in Figure 4. The first image is a 2D graphical user interface based on standard Windows-GUI elements. However, there is also an intuitive placement tool available. It is shown on the right side of Figure 4. This tool uses Mixed Reality technology to place geometry

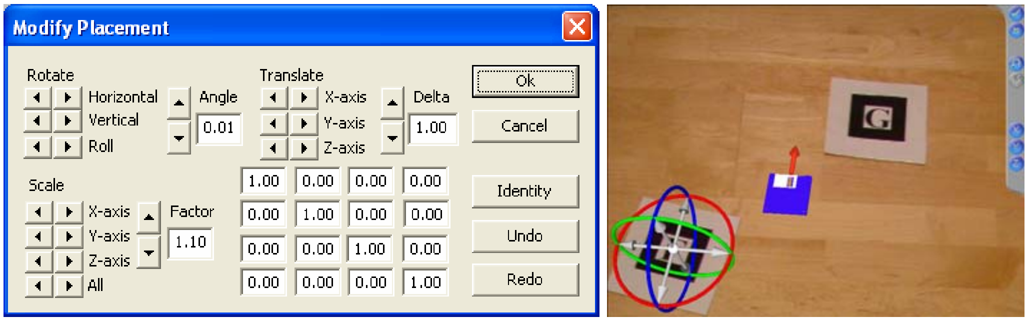

Figure 4: GUI based and AR based placement tool.

6. Results and Future Work

First tests of the refinery MR application have shown that users liked a trainig program based on MR technology and based on a Tablet-PC approach. An HMD never would work in a real environment (e.g. in a refinery) because of many reasons – one of them is safety. The time saved during the authoring process showed the strengths of the authoring process. Especially the possibility of reusing parts of the application by drag&drop of components in a visual authoring tool increases the authoring process. Calibration is one of the most complicated tasks in authoring and has to be improved in future work. During our calibration tasks of geometry we realized that a refinery is one of the worst scenarios for ARToolKit. First, it is difficult to find flat, large surfaces where the markers can be placed. Second, because an oil refinery is a very complex area full of reflecting pipes and machines.

In the next steps we have to extend the content of the application and show the benefits of an MR training application for the refinery. Furthermore, we have to find a better tracking system to get a better acceptance of the application among the refinery trainees. Consequently, one goal is to integrate Fua's feature-point tracking system [9] into AMIRE. Adding new components isn't a hard task for AMIRE, because of its component oriented approach that allows adding new content and components without changing the base of the application.

7. References

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